The Journal
of Research
on the Lepidoptera

Volume 46: 1-21

THE LEPIDOPTERA RESEARCH FOUNDATION, 1 May 2013

ISSN 0022-4324 (print)
ISSN 2156-5457 (online)

Neotropical palm-inflorescence feeding moths (Lepidoptera: Batrachedridae, Blastobasidae, Cosmopterigidae, Gelechiidae, Pyralidae, Tineidae): a review of the literature and new records from Trinidad, West Indies

Matthew J.W. Cock[1*] and Dwayne H. Burris[2]
[1]CABI E-UK, Bakeham Lane, Egham, TW20 9TY, UK
[2]UNEP-GEF Project Mitigating the Treats of Invasive Alien Species in the Insular Caribbean, Ministry of Food Production, Land & Marine Affairs, Research Division, Central Experiment Station, Caroni North Bank Road, Centeno, Trinidad and Tobago; current address: #30 Bay View Boulevard, Bay View La-Romain, Trinidad and Tobago
m.cock@cabi.org, mjwcock@btinternet.com, dwayne.h.b@gmail.com

Abstract. The insects associated with the inflorescences of palms (Arecaceae) and their roles as pollinators, pests and scavengers are not well known compared to foliage-feeders and trunk borers, especially in the Neotropical Region. A literature review of the Lepidoptera associated with palm inflorescences in the Neotropical Region is provided. In a preliminary survey of Lepidoptera associated with palm inflorescences in Trinidad (Trinidad and Tobago), more than one thousand moths of 12 species were reared from six of the 14 palm species sampled. Of the moths reared, three could not be identified beyond family, three could be identified only to genus, and the remaining six were identified to species. These six comprise two species that feed on flowers of *Cocos nucifera* and *Roystonea oleracea* (viz. *Atheloca bondari, Batrachedra nuciferae*) and four that are polyphagous, widespread detritivores (*Xystrologa nigrivitta, Anatrachyntis rileyi, Erechthias minuscula, Phidotricha erigens*). *Anatrachyntis rileyi* and *E. minuscula* are thought to be introduced moth species, while the others are indigenous. Biological observations are presented on the moths reared.

Keywords: *Anatrachyntis rileyi, Atheloca bondari, Batrachedra nuciferae, Erechthias minuscula, Holcocera* sp., *Neodavisia* sp., *Phidotricha erigens, Xystrologa nigrivitta,* Arecaceae, coconut.

Introduction

The insects associated with palms (Arecaceae), especially *Cocos nucifera* (coconut), have been relatively well documented (Lepesme, 1947; Lever, 1979; Howard *et al.*, 2001), but those associated specifically with the inflorescences and their roles as pollinators, pests and scavengers are less well known. Traditionally, palms were thought to be wind pollinated, but it has become clear in recent decades that insect pollination does occur and may well be the norm rather than the exception (Moore, 2001). The floral ecology is variable among species (Henderson, 1986). Some have hermaphrodite flowers, others are monoecious (containing flowers of both sexes) in the same inflorescence, and others are dioecious (each palm bears either male or female inflorescences). Some maintain male flowers for several days, and stagger their maturation; others mature all the male flowers on an inflorescence at once and drop them all within a day. *A priori*, the former are likely to be suitable for the development of insects, whereas the latter are not (Moore, 2001).

The caterpillars of Lepidoptera found in palm inflorescences are either herbivorous or detritivorous species. The plant feeding species range from those that feed purely on pollen in the male flowers, to those that feed on the structures of the male flowers, female flowers, developing nuts, and inflorescence branches. Obviously, these have different implications for the fecundity of the palms, and production of nuts where this is an economic consideration, e.g. coconuts. However, as yet very little is known about the ability of palms to compensate for insect damage to their inflorescences (Cock *et al.*, 1987; Waterhouse & Norris, 1987; Moore, 2001).

**Corresponding author*

Received: 25 February 2013
Accepted: 29 March 2013

The native palms of Trinidad and Tobago were treated by Comeau *et al.* (2003). There are 22 native species in 15 genera and they are an important feature of the country's landscape and biodiversity. Coconut is an introduced species in Trinidad of many years standing. It is found in cultivation throughout the island, usually near dwellings or former dwellings, but has not naturalised on any great scale.

This paper summarises published information on the Lepidoptera associated with the inflorescences of coconut and other palms in South America, and reports new observations from a preliminary survey of several indigenous and introduced palms in Trinidad, West Indies. The survey was focused on *Batrachedra nuciferae* Hodges (Lepidoptera: Batrachedridae), to establish its status and host range in Trinidad, to help assess the need and options for its management, as reported in Cock (2013). A second component of the survey was to collect information on what other species of small Lepidoptera feed on the same host palms as *B. nuciferae*, so that early stages and damage by *B. nuciferae* could be distinguished from those of other Lepidoptera. Here we present observations on the biology and host range of the Lepidoptera species associated with selected palms in Trinidad.

Methods

A literature survey was made of the known palm-inflorescence feeding Lepidoptera in the Neotropical Region. This was based on key reference works (Lepesme, 1947; Howard *et al.*, 2001) and the references therein, and by searching CAB Abstracts to establish which species have been recorded from palm inflorescences in the area. Once the names of Lepidoptera species were found, further searches were made, including consulting the original descriptions and selected taxonomic and general works that might deal with these species, as well as internet searches, and relevant references compiled from these sources. The collection of the Natural History Museum, London (BMNH) was examined and biological and distribution data recorded for relevant species.

The field and laboratory methods and palms sampled are described in Cock (2013), and only outlined here. The fourteen species of palms that were sampled are presented in Table 1. Whole inflorescences and/or dropped male flowers were taken for each sample (Table 2). They were inspected visually in the laboratory, and caterpillars and cocoons on them were documented. The samples were then set up in emergence boxes for whole inflorescences or in plastic rearing containers for subsamples to rear out adult moths, which were recorded daily.

Because the field work was carried out during a short period in October 2011, it was not possible to sample all palm inflorescences at the same stage of development, and this will have affected the species and numbers of moths obtained. The condition of each sample is listed in Table 2 and notes on each sample are provided.

Samples of coconut flowers were obtained from five localities. Coconut is monoecious, and because it flowers continuously (Child, 1974), there was little difficulty taking samples with pollen-producing male flowers that were attracting insects.

The next seven species of palm are considered indigenous (Comeau *et al.*, 2003). Male and female flowers of *Attalea maripa* are born on separate inflorescences, but the floral biology and ecology of the genus is poorly understood and may vary with the age of the palm (Henderson *et al.*, 1995). The male flowers of *A. maripa* consist of little more than a bunch of pollen-bearing stamens, so they are very different in structure from all the other palms that we sampled. Although *A. maripa* was common at Bush Bush Island in Nariva Swamp, most palms were too tall to sample, and only an unopened spathe and an old dead male inflorescence from a shorter palm could be sampled. The unopened spathe was unblemished, with no signs of insect damage.

Bactris major is monoecious; the male flowers release pollen for about 24 hours and then are dropped immediately (Essig, 1971; Henderson, 1986). It seems likely that this short period of pollen-producing male flowers would make it very difficult for a pollen-feeding caterpillar to establish itself and survive. No trace of Lepidoptera feeding was found on the inflorescences sampled, and no moths were reared. Caterpillars, particularly of detritivorous species, theoretically could develop on the fallen flowers, but a 40ml sample of newly fallen flowers collected at the Botanic Gardens showed no signs of Lepidoptera feeding (visual inspection and dissection of ten flowers), and none were reared. *Bactris simplicifrons* has small inflorescences, each having only a few male and female flowers. We did not find any inflorescences with male flowers, but two inflorescences that had recently dropped their male flowers showed no trace of Lepidoptera or other insect damage.

All the male flowers had dropped, and only green developing nuts remained on the inflorescence sample of *Euterpe precatoria*. Examination of the branches from which the male flowers had dropped showed no signs of Lepidoptera damage, and specifically no sign of male flowers attached to the inflorescence by silk, or of cocoons. One of the hundreds of developing nuts was black rather than green and it contained

Table 1. The palms (Arecaceae) of which inflorescences were sampled, Trinidad, October 2011. Classification follows Dransfield *et al.* (2008) as presented by Trebrown Nurseries (2011); common names and their distributions are based on Comeau *et al.* (2003).

Subfamily, Tribe (subtribe)	Species	Common name in Trinidad	Distribution in Trinidad
Arecoideae, Areceae (Ptychospermatinae)	*Adonidia merrillii*	Manila palm	Introduced ornamental; widespread and common
Arecoideae, Areceae (Ptychospermatinae)	*Ptychosperma macarthurii*	Hurricane palm	Introduced ornamental; widespread and common
Arecoideae, Cocoseae (Attaleinae)	*Cocos nucifera*	Coconut	Introduced; cultivated in all except highest parts
Arecoideae, Cocoseae (Attaleinae)	*Attalea maripa*	Cocorite	Widespread except highest parts
Arecoideae, Cocoseae (Attaleinae)	*Syagrus romanzoffiana*	Queen palm	Introduced ornamental
Arecoideae, Cocoseae (Bactridinae)	*Bactris major*	Roseau, picmoc, black roseau	Widespread but absent from Northern Range and Long Stretch
Arecoideae, Cocoseae (Bactridinae)	*Bactris simplicifrons*	Yuyu	Local, scattered
Arecoideae, Cocoseae (Euterpeae)	*Euterpe oleracea*	Manac	Widespread at low elevations
Arecoideae, Roystoneae	*Roystonea oleracea*	Palmiste, royal palm, cabbage palm	Possibly introduced; S & E coasts, widespread as cultivated
Calamoideae Calameae (Calaminae)	*Calamus* sp.	Rattan palm	Introduced ornamental
Calamoideae, Lepidocaryeae (Mauritiinae)	*Mauritia flexuosa*	Moriche	Local especially Nariva Swamp, Long Stretch
Coryphoideae, Sabaleae	*Sabal mauritiiformis*	Carat	South, widespread
Coryphoideae, Trachycarpeae (Livistoninae)	*Licuala spinosa*	Spiny licuala palm	Introduced ornamental
Coryphoideae, Trachycarpeae (unplaced)	*Pritchardia pacifica*	Fiji fan palm	Introduced ornamental

a small Lepidoptera caterpillar. It was not reared successfully and no moths were obtained from the emergence box.

Individual *Mauritia flexuosa* palms are dioecious; they bear inflorescences of either male or female flowers, not both (Ervig, 1993). We found one male palm at Aripo Savannah that was short enough to sample. It had several young, yellow-green inflorescences whose flowers had not yet opened, and several old dead, dark brown inflorescences; we collected one of each. The young inflorescence showed no sign of Lepidoptera damage when inspected, although moths were obtained by emergence box. Some feeding damage and very small caterpillars were found under the bracts of the old inflorescence, and adult moths were obtained by emergence box.

Roystonea oleracea is monoecious. An unusual feature of the genus is that from before the spathe opens, it is packed with millions of very small, fluffy, branched hairs (Henderson *et al.*, 1995). We were able to sample one inflorescence from a relatively short palm at Kernahan. In this inflorescence, the male flowers had recently dropped and the female flowers were small. Many of the male flowers and the fluffy matrix were caught up in the inflorescence and the spathe, which remained in place below the inflorescence. More than 600 moths were reared from this one inflorescence. It seems likely that the fluffy matrix contained in inflorescences of *R. oleracea* provides a food source that can support many caterpillars of some of these moths, although we did not attempt to establish this.

Sabal mauritiiformis is unusual amongst the indigenous palms sampled in that the small flowers are bisexual (Henderson *et al.*, 1995), and hence they are not dropped once pollen production is complete. Two palms were examined at Kernahan; one had an

Table 2. Collections of palm inflorescences made in Trinidad, 8-18 October 2011. All sample sites were less than 50m asl.

Date	Palm species	Location	GPS	Details
8 Oct	*Adonidia merrillii**	Curepe, CABI	N10°39.159 W61°24.065	1 inflorescence
12 Oct	*Attalea maripa*	Nariva Swamp, Bush Bush Is. (North)	N10°23.726 W61°02.381	1 unopened male inflorescence, 1 old male inflorescence
18 Oct	*Bactris major*	Botanic Gardens	N10 40°426 W61°30.913	Fallen male flowers
12 Oct	*Bactris major*	Nariva Swamp, Bush Bush Is. (North)	N10°23.730 W61°02.375	1 old inflorescence
14 Oct	*Bactris simplicifrons*	Nariva Swamp, Bush Bush Is. (South)	N10 23°390 W61°02.711	2 old inflorescence
18 Oct	*Calamus* sp.*	Botanic Gardens	N10 40°460 W61°30.888	2 old inflorescence
12 Oct	*Cocos nucifera*	Nariva Swamp, Bush Bush Is. (North)		1 inflorescence
10 Oct	*Cocos nucifera*	Centeno		Fallen male flowers
8 Oct	*Cocos nucifera*	Curepe, CABI (palm NL1)	N10°39.182 W61°24.069	1 inflorescence
8 Oct	*Cocos nucifera*	Curepe, CABI (palm TRT08)	N10°39.184 W61°24.074	1 inflorescence
8 Oct	*Cocos nucifera*	Curepe, CABI (palm TRT09)		1 inflorescence
12 Oct	*Cocos nucifera*	Nariva Swamp, Kernahan**	N10 21°490 W61°00.856	1 inflorescence
10 Oct	*Cocos nucifera*	Waller Field, Gafoor's Plantation	N10°39.177 W61°14.231	2 inflorescence
14 Oct	*Euterpe precatoria*	Aripo Savannah	N10 35°476 W61°11.338	1 old inflorescence
18 Oct	*Licuala spinosa**	Botanic Gardens	N10 40°424 W61°30.913	1 old inflorescence
14 Oct	*Mauritia flexuosa*	Aripo Savannah, KP Quarry section	N10 36°352 W61°12.384	1 young inflorescence, 1 old inflorescence
18 Oct	*Pritchardia pacifica**	Botanic Gardens	N10 40°427 W61°30.984	2 inflorescence (pooled)
18 Oct	*Ptychosperma macarthurii**	Botanic Gardens	N10 40°423 W61°30.939	1 inflorescence
8 Oct	*Ptychosperma macarthurii**	Curepe, CABI	N10°39.170 W61°24.086	several bits of inflorescence
18 Oct	*Roystonea oleracea*	Botanic Gardens	N10 40°428 W61°30.924	Fallen male flowers
12 Oct	*Roystonea oleracea*	Nariva Swamp, Kernahan**	N10 21°415 W61°00.869	1 inflorescence
12 Oct	*Sabal mauritiformis*	Nariva Swamp, Kernahan**	N10 22°207 W61°01.618	1 inflorescence
18 Oct	*Syagrus romanzoffiana**	Botanic Gardens	N10 40°422 W61°30.933	1 inflorescence; fallen male flowers

*Introduced ornamental species.

**Also spelt Kernaham.

inflorescence that included open male flowers and this was sampled. Small caterpillars of a *Batrachedra* sp. were found.

The following six palms are introduced, ornamental species. *Adonidia merrillii* is monoecious, but the opening of the male flowers is staggered, so that only a few are open at a time. No sign of Lepidoptera feeding could be found in the inflorescence of the palms sampled, and none were obtained by emergence box.

Our sample of *Calamus* sp. in the Royal Botanic Gardens was two old, dry male inflorescences, comprising a densely packed mass of dry dead flowers. Examination showed some webbing and caterpillar frass in most parts of the inflorescence, and caterpillars with a dark head and dark purplish body were associated with this. Two cocoons were found but nothing emerged from these or in the emergence box, so we cannot confirm whether this species is a

suitable food plant for any of the Lepidoptera found in our survey, but certainly it is host to at least one species of Lepidoptera.

Licuala spinosa has bisexual flowers, and although each flower produces pollen only briefly, the inflorescence produces mature flowers over a period of about a month (Barfod *et al.*, 2003). We were able to obtain only an old inflorescence, from which most of the flowers were long gone, and on which some nuts were beginning to develop. The inflorescence showed no sign of Lepidoptera feeding, webbing or cocoons, but probably it was too old to expect to see this.

Pritchardia pacifica is monoecious. In addition to two inflorescences, we collected male flowers that had dropped and caught amongst the branches of an older inflorescence; there was light webbing and frass amongst these dropped male flowers and moths were obtained by emergence box.

Ptychosperma macarthurii is monoecious, and the male flowers are not synchronised. Thus we were able to find small numbers of scattered male flowers on the inflorescences that we sampled, and some flowers that dropped and got caught up between the inflorescence branches in one sample. There was no trace of webbing or frass on either the fresh or dropped male flowers, and no Lepidoptera were obtained by emergence box.

Syagrus romanzoffiana is monoecious but the one that we sampled had already dropped most of the male flowers. The inflorescence seemed completely healthy except that the ends of many apical secondary branches were trapped in the narrow apex of the spathe, together with many male flowers that had started to become mouldy. This situation seemed ideal for attack by Lepidoptera yet there was no trace of caterpillar damage. A small collection of dropped male flowers was also made from the base of the palm and set up separately. No Lepidoptera emerged from either sample.

Obtaining samples was a significant challenge, due to limited availability of flowers at the selected sites in the week of the survey, and those palms which were flowering were often too tall to sample safely. The samples obtained were not necessarily at the best stage to look for flower feeding caterpillars, especially those that feed on pollen, such as *Batrachedra* spp. Nevertheless, because Lepidoptera feeding leaves recognisable traces, such as webbing, frass and cocoons, old inflorescences where the dead male flowers were still present provided useful information.

Examination of inflorescences in the laboratory gave fairly reliable insight into the species present and their damage, but overlooked eggs or very young individuals, and risked overlooking very low density populations. As a measure of population density, taking a sample at a single time point as we did, unavoidably makes no allowance for eggs that would have been laid in the inflorescence after collection, nor for moths that had already emerged before the sample was taken. By carefully examining the material before setting it up in the emergence box, we have a qualitative control for the latter aspect, but we could not control for the former.

Nevertheless, there was wide variation in the numbers of moths obtained from the emergence boxes, and large numbers of moths were obtained in several cases, so that this method does provide a time-efficient and cost-effective way to recognise the relative density of populations of Lepidoptera in the different inflorescences at the time of sampling. Any more rigorous approach would inevitably be much more expensive in time and money, so we believe this is a practical and appropriate approach.

Results: Literature survey

Until recently, there has been little work on the Lepidoptera that breed in palm inflorescences in the Neotropical Region, and almost none of a general nature. Hence, the early work of Bondar (1940a, 1940b) in Bahia, Brazil, is still an important source of information on Lepidoptera that develop in the inflorescences of coconut (*Cocos nucifera*) and other palms. Bondar deals with *Batrachedra nuciferae* (as *B. perobtusa* Meyrick, a misidentification), and two more damaging species: *Atheloca bondari* Heinrich (as *Hyalospila ptychis* Dyar, a misidentification or synonym, see below) and *Cadra cautella* (Walker) (as *Ephestia cautella*). In addition, there is limited information on a small number of other moths recorded from coconut, mostly noted by Lepesme (1947) in his standard reference *Les Insectes des Palmiers*. The summary by Moore (2001) in the recent equivalent title *Insects on Palms* (Howard *et al.*, 2001) adds very little for the Neotropical Region to what Bondar and Lepesme reported. Species not previously recorded from palm inflorescences were reared in this survey, and the available literature on these species is also summarised here. An overview of the literature survey is provided as Table 3.

Atheloca sp(p). (Pyralidae, Phycitinae)

Atheloca bondari was described by Heinrich (1956) in his revision of the American Phycitinae, based on Bondar's specimens in the United States National Museum. There is a very similar species, *A. subrufella* (Hulst) (=*Hyalospila ptychis*), found in Florida (USA),

Table 3. An overview of the Lepidoptera associated with palm inflorescences in the Neotropical Region, based on this literature review.

Species	Classification	Host plants	Feeding on	Distribution	Key references
Anatrachyntis rileyi (Walsingham)	Cosmopterigidae	Many plant hosts	Detritus	Old World origin, southern USA, Caribbean	Walsingham, 1882; Busck, 1917; Heinrich, 1921; Hodges, 1978; Zimmerman, 1978
Atheloca bondari (Heinrich)	Pyralidae, Phycitinae	*Cocos nucifera*, *Syagrus* spp., *Attalea spp.*	Male and female flowers	Brazil, Trinidad (this survey)	Bondar, 1940a, 1940b; Heinrich, 1956. As *A. subrufella*: Santana, 2008; Santana *et al.*, 2009, 2010, 2011
Atheloca subrufella (Hulst)	Pyralidae, Phycitinae	*Cocos nucifera, Sabal palmetto, Serenoa repens*	Male and female flowers	Florida, Caribbean (unconfirmed: French Guiana)	Heinrich, 1956; Kimball, 1965; Habeck & Nickersen, 1982; Schotman, 1989; Bento *et al.*, 2006
Batrachedra nuciferae Hodges	Batrachedridae	*Cocos nucifera* (unconfirmed: *Syagrus* spp., *Attalea spp.*)	Pollen of male flowers (unconfirmed: female flowers)	Brazil, Venezuela, Trinidad, probably widespread in South America	Bondar, 1940a, 1940b; Hodges, 1966; Arnal *et al.*, 1998; Sanchéz Soto, 2004; Sánchez-Soto & Nakano, 2002, 2004a, 2004b, 2008; Cock 2013
Cadra cautella (Walker)	Pyralidae, Phycitinae	Usually on stored products	Male and female flowers	Cosmopolitan	Bondar, 1940a, 1940b
Erechthias minuscula (Walsingham)	Tineidae, Erechthiinae	Many plant hosts	Detritus	Old World origin, southern USA, Caribbean	Walsingham, 1897; Swezey, 1909; Lepesme, 1947; Clarke, 1971; Zimmerman, 1978; Clarke, 1986
Holcocera ochrobathra (Meyrick)	Blastobasidae, Holcocerinae	*Cocos nucifera*	Detritus	Guyana, Florida	Meyrick 1921; Bodkin 1922; Adamski, 2002b; Heppner, 2003
Phidotricha erigens (Ragonot)	Pyralidae: Epipaschiinae	Polyphagous	Reproductive parts and leaves of diverse plants	Neotropical	Solis, 1993, 2011; Diniz & Morais, 2002
Xystrologa nigrivitta (Walsingham)	Tineidae, ?Meesiinae	Several plant hosts	Bracket fungus, *Roystonea oleracea* inflorescence (this survey); probably diverse materials	Caribbean	Davis *et al.*, 2012

Cuba and the Virgin Is., which differs primarily in the absence of 'a strong, dorsal, yellow hair tuft from the base of the male hind tibia' found only in *A. bondari* (Heinrich, 1956). Heinrich illustrates the male and female genitalia of *A. subrufella*, which show 'no essential differences' from those of *A. bondari*. Pictures of adult moths of *A. subrufella* can be seen at MPGNA (2012). Schotman (1989) reports *A. subrufella* from French Guiana and St. Lucia. Although the two species were considered distinct in Shaffer's (1995) treatment in the checklist of Neotropical Lepidoptera and though they do not seem to have been formally synonymised since (e.g. Beccaloni *et al.*, 2003), they are likely to be synonyms (M.A. Solis, pers. comm., 2012). Nevertheless, we maintain both names here in line with formal taxonomy and pending a critical study of the question.

Bondar (1940a, 1940b) found that the caterpillars of *A. bondari* feed on both male and female flowers of coconut, as well as on the flowers of the native palms of the genera *Syagrus* (as *Cocos*) and *Attalea*. He illustrated the damage to male coconut flowers, which includes holes eaten through the sides of the male flowers; damage to the female flowers causes abortion or early nut fall.

Cabbage palm (*Sabal palmetto*) and saw palmetto (*Serenoa repens*) (Arecaceae) have been reported as food plants of *A. subrufella* in Florida (Kimball, 1965), and Habeck & Nickersen (1982) subsequently

described the biology on coconut thus: 'Larvae feed on newly emerged inflorescences and destroy flower buds and young developing coconuts. Coconuts up to 1.5 inches in diameter may be completely hollowed out. Larvae spin silk over the inflorescences ... and incorporate frass and plant material into the webs. Pupation occurs amid the plant material under the webbing.' Bento *et al.* (2006) describe the biology and mating behaviour in more detail. S.W.J. de Santana studied the life history and bioecology of *A. subrufella* in Pernambuco State, Brazil for her PhD thesis (Santana, 2008), and published accounts of the rearing method (Santana *et al.*, 2011), thermal biology (Santana *et al.*, 2010) and interaction with coconut mite, *Aceria guerreronis* Keifer (Santana *et al.*, 2009). Santana (2008) and Bento *et al.* (2006) both treat *Atheloca bondari* and the reports on its biology as though it is a synonym of *A. subrufella*.

***Cadra cautella* (Walker) (Pyralidae, Phycitinae)**

Cadra cautella is a well-known stored products pest found throughout tropical and temperate areas (Heinrich, 1956; Mound, 1989). Bondar (1940a, 1940b) reports that the caterpillars feed on male and female flowers of '*Cocos* spp.' (i.e. *C. nucifera* and *Syagrus* spp.) and *Attalea* spp. It should be noted that *Cadra* includes several similar species, with similar biology as stored product pests, and dissection of the genitalia is usually needed to confirm their identification (e.g. Goater, 1986; Mound, 1989); accordingly this identification needs species level confirmation. For the identification of the larvae, see Mound (1989) and Solis (2011).

***Phidotricha erigens* (Ragonot) (Pyralidae: Epipaschiinae)**

Phidotricha erigens, described from Puerto Rico (Ragonot, 1888), is found throughout the Caribbean and adjoining mainland, south to Brazil (Solis, 1993, 2011). In the past *P. erigens* has been treated as a synonym of *Pococera atramentalis* Lederer (1863). This would have been because *Phidotricha erigens* was identified as *Pococera atramentalis* in the collection of the Natural History Museum, London (BMNH). However, although the BMNH series of *Pococera atramentalis* are *Phidotricha erigens* (or were until curated), the holotype of *Pococera atramentalis* (also in the BMNH) is a different species (Solis, 1993).

Phidotricha erigens is known to be polyphagous on the leaves and reproductive parts of a wide variety of plants including Anacardiaceae, Calophyllaceae, Cucurbitaceae, Fabaceae, Oxalidaceae, Malvaceae, Rutaceae, Passifloraceae, Phytolaccaceae, Poaceae, Rosaceae, Zingiberaceae (Solis, 1993, 2011), Burseraceae, Celastraceae, Erythroxylaceae, Fabaceae, Vochysiaceae (Diniz & Morais, 2002), Asparagaceae (Velázquez *et al.*, 2010), and Caryocaraceae (Carregaro, 2007), but not hitherto from Arecaceae. The possibility that these records represent several cryptic species with more specialised food plant preferences has not been investigated.

This species has previously been reported from Trinidad, based on specimens reared by F.W. Urich as *Pococera atramentalis* (Kaye & Lamont, 1927). Some of F.W. Urich's specimens are in the United States National Museum, Washington; they were reared in November 1922 from *Albizia saman* (Fabaceae). It also has been reared from flowers of *Tephrosia* sp. (Fabaceae), in October 1954 at St. Augustine, Trinidad, by F.D. Bennett (specimen in University of the West Indies Zoology Museum). The species occurs also in Tobago (M.J.W. Cock unpublished).

***Batrachedra* spp. (Batrachedridae)**

The genus *Batrachedra* is usually placed in the family Batrachedridae of the Gelechioidea (Hodges, 1999; Brown *et al.*, 2004; Kaila *et al.*, 2011; van Nieukerken *et al.*, 2011), but has also been placed in the subfamily Batrachedrinae of the Coleophoridae (Becker, 1984; Kaila, 2004). The family Batrachedridae is considered paraphyletic (Kaila, 2004; Kaila *et al.*, 2011), so further changes may follow.

Hodges (1966) revised the American *Batrachedra* spp. and recognised three groups of species within the genus. One of these groups includes three species feeding on palm inflorescences, one feeding on the base of the pineapple fruiting body, and six of unknown biology. Positive identification of these species is only possible based on dissection and examination of the genitalia, those of the female being more diagnostic than those of the male. *Batrachedra nuciferae* is discussed below; *B. mathesoni* Busck occurs in Florida and the caterpillars feed on coconut flowers; and *B. decoctor* Hodges also occurs in Florida where the palm *Serenoa repens* is a food plant. Other *Batrachedra* spp. of this group have been described from Puerto Rico, Jamaica, St Lucia and Central America, etc. *Batrachedra arenosella* (Walker) is the name applied to a *Batrachedra* species in South-East Asia and Australasia which also has been reported to feed on coconut inflorescence, causing insignificant damage (Corbett & Gater, 1924; Kalshoven & van den Laan, 1981). However, most probably this name is incorrectly applied, as *B. arenosella* was described from New Zealand, where it is known as a scale predator (Moore, 2001).

At least two species of *Batrachedra* feed as caterpillars in the inflorescences of palms in Trinidad (Cock, 2013), *B. nuciferae* on coconut and *Roystonea oleracea*, and an unidentified species on *Sabal mauritiformis*. It seems likely that other species of this group of American *Batrachedra* spp. will be found to feed on palms, probably showing some specialisation as to species or genera that are acceptable as food plants.

***Batrachedra nuciferae* Hodges (Batrachedridae)**

Batrachedra nuciferae was first recognised by Bondar (1940a, 1940b) who described its biology in Bahia State, Brazil (as *B. perobtusa*). It was subsequently described as a new taxon, based on Bondar's material reared from male coconut flowers, in Hodges' (1966) revision of the American *Batrachedra*. The species description was based only on material reared from coconut and Hodges did not refer to material from the other palms which Bondar (1940a, 1940b) records as food plants. Moore (2001) summarises Bondar's observations under the name *Ifeda perobtusa*, overlooking the name change in Hodges' (1966) revision. In 1998, *B. nuciferae* was recorded from Venezuela as a new pest of coconut (Arnal *et al.*, 1998). In 2006, *B. nuciferae* was correctly reported from Trinidad as a new pest of coconut (MALMR, 2006, 2008), although the adult moth shown in MALMR (2008) is *Anatrachyntis rileyi* (Walsingham) (reported below as reared from palm inflorescences).

Bondar (1940a, 1940b) reported that the caterpillars of *B. nuciferae* rest in the male flowers of coconut where they feed on pollen, and they are also common in the flowers of several other palms: *Syagrus coronata* (=*Cocos coronata*), *S. vagans* (=*C. vagans*), *S. schizophylla* (=*C. schizophylla*), *Attalea funifera* and *A. piassabossu*. He considered that the damage to male flowers reduced the probability of fertilization of female flowers and hence could adversely affect nut production, but presented no evidence for this conclusion. He gives brief descriptions of the caterpillar and pupa, states that the cocoon is formed on a solid substrate or amongst the fallen male flowers in the leaf axil below, and that the life cycle takes 15-18 days.

Since 1940, there was almost no published work on the coconut moth, until the work of S. Sanchéz-Soto in São Paulo State, Brazil, this century. The moth was the subject of his research thesis (Sanchéz Soto, 2004) and publications on the distribution (Sánchez-Soto & Nakano, 2002, 2004a), morphology (Sánchez-Soto & Nakano, 2004b), and biology (Sánchez-Soto & Nakano, 2008). The egg, caterpillar (including chaetotaxy), pupa and adult are illustrated in both Sánchez Soto (2004) and Sánchez-Soto & Nakano (2004b).

Arnal *et al.* (1998) reported the presence of the moth in several parts of Venezuela. Carneiro *et al.* (2004) stated that in the Município de Parnaíba, Piauí, north-east Brazil, the caterpillars eat both male and female flowers. Observations from Trinidad were reported by Cock (2013), who found no evidence that female flowers were damaged. His observations showed that the inflorescence of *Roystonea oleracea* is also used as a food source, but that no *B. nuciferae* were obtained from inflorescences sampled from 12 other indigenous and introduced palms, including *Attalea maripa*.

***Holcocera ochrobathra* (Meyrick) (Blastobasidae, Holcocerinae)**

Although some recent works treat Blastobasidae as a subfamily of Coleophoridae (Hodges, 1999), it is retained as a family here in line with van Nieukerken *et al.* (2011). Species of Blastobasidae are usually considered to be scavengers or detritivores on a variety of substrates, but some are herbivorous (Adamski & Brown, 1989). The North American species have been revised and arranged in two subfamilies and several genera (Adamski & Brown, 1989), but the South American species are still poorly known (Adamski, 2002b), apart from those of Costa Rica (Adamski, 2002a, 2013). There are many undescribed species (Adamski & Brown, 1989; Adamski, 2002b).

Meyrick (1921) described *H. ochrobathra* from Guyana, in the genus *Blastobasis*, based on specimens reared from coconut flowers by L.D. Cleare Jr. in 1920, and stated that the type was in the 'Brit. Mus.' (BMNH). There are four such specimens in the BMNH, of which a male is designated lectotype and has been dissected and illustrated by Clarke (1963), and a female has been designated paralectotype. Adamski (2002b) reported four further paratypes in the US National Museum. In the British Guiana Department of Science and Agriculture Annual Report for 1920, Bodkin (1922, as abstracted in *Review of Applied Entomology*) reported "In one district the blossoms of the palms were found to be infested by the larvae of a small moth, *Blastobasis ochrobathra*, Meyr." Although this species did not appear in the Lepidoptera of North America checklist (Hodges *et al.*, 1983), it is recorded from Florida (Heppner, 2003). In his synopsis of the Neotropical Blastobasidae, Adamski (2002b) transferred *ochrobathra* to *Holcocera*, but noted that it is known only from the type locality. Heppner (2003) placed this species in *Blastobasis* rather than *Holcocera*, but we follow Adamski (2002b) here. We note that there is a Barbados specimen in the BMNH reared

from castor oil seeds by R.W.E. Tucker, December 1937, although its identity has not been confirmed by dissection.

There is a similar species, *H. grenadensis* (Walsingham, 1891), described from Grenada. The female lectotype and four paralectotypes from Grenada and Dominica are in the BMNH (Adamski, 2002b), together with specimens from Barbados and the Bahamas, which have not been dissected to confirm their identity. Adamski (1998) treated this species and transferred it to the genus *Holcocera*. Some authorities still (or again) place it in *Blastobasis* (e.g. Lee & Brown, 2009a), but we follow Adamski's (2002b) treatment here. On external appearance, *H. grenadensis* differs from *H. ochrobathra* primarily in that the forewings are irregularly streaked with pale brown scales (Adamski, 2002b), but both species are variable. The two species can also be differentiated by characters of the genitalia (Adamski, 2002b). The male and female genitalia have been figured (Clarke, 1963; Adamski, 1998, 2002b). Given the general similarities of species in this subfamily, even between genera, support from DNA barcoding (Hajibabaei, *et al.*, 2007; Janzen *et al.*, 2009; Adamski *et al.*, 2010) might simplify identifications in future.

***Anatrachyntis rileyi* (Walsingham) (Cosmopterigidae)**

Anatrachyntis (Meyrick, 1915a) is a genus of more than 50 species of small moths, almost exclusively from the Old World. The species of known biology seem to be scavengers and several have been associated with palm inflorescences. *Anatrachyntis simplex* (Walsingham) was described from Africa, but is now found in many parts of the tropics, and recognised as a polyphagous scavenger on various crops including cotton and coconut (Lepesme, 1947). Other species of this genus have been recognised as feeding on coconut flowers in the Old World, including, *A. paroditis* (Meyrick) in South-east Asia (Corbett, 1922), the Pacific (Lever, 1938), and the Seychelles (Vesey-Fitzgerald ,1941) etc., and *A. dactyliota* (Meyrick) is recorded in Malaysia (Meyrick, 1931).

Although *A. rileyi* was described from Georgia, USA (Walsingham, 1882), and is known from the USA and several Caribbean Islands, it is likely to be of Old World origin, perhaps from Africa (Meyrick, 1915a, p. 326; Zimmerman, 1978) and is widespread from southern Asia through the Pacific. At different times it has been placed in the genera: *Batrachedra* (Walsingham, 1882), *Sathrobrota* (Hodges, 1962), and *Pyroderces* (Hodges, 1978). At about the same time that Hodges (1978) placed *rileyi* in *Pyroderces* in his treatment of the family in the standard reference *The Moths of America North of Mexico*, Zimmerman (1978) transferred *rileyi* to *Anatrachyntis*. The latter has become accepted by European authors (e.g. Koster & Sinev, 2003; Heckford & Sterling, 2004), while *Pyroderces* is still commonly used in North America (e.g. Lee & Brown, 2009b).

There is a similar species, *A. badia* (Hodges) in the USA, which was described in 1962 and has a similar range of food materials but with little documented overlap of actual food plant species (Hodges, 1962); the two are separated by markings on the hind leg tibia (Hodges, 1978). Where the two species occur together they could easily be confused, and this would have been the case with publications from the first half of the 20th century (Zimmerman, 1978). The caterpillars of *P. rileyi* have been described by Busck (1917) and Heinrich (1921) and those of *P. badia* by Adamski *et al.* (2006), who could find no diagnostic characters to separate caterpillars of the two species.

The caterpillars are detritivores reared from a wide variety of plant materials including cotton bolls (Walsingham, 1882; Busck, 1917; Heinrich, 1921), as well as flowers, beans and pods of *Ricinus* (castor oil; Euphorbiaceae), flowers of *Hyptis* sp. (Lamiaceae), *Colocasia esculenta* (dasheen; Araceae), maize (corn husks and tassels, stored corn), many kinds of old leguminous pods, aloe, coffee beans, coffee cherries, eggplant, banana, dead *Panicum torridum*, pineapple (dried parts, fruits, stored seeds), *Rochea* (Crassulaceae), *Samanea saman* (Fabaceae-Mimosoideae), *Sapindus oahuensis* (Sapindaceae), and tamarind (Hodges, 1962, 1978; Zimmerman, 1978; Garraway *et al.*, 2007). Although *A. badia* has been reported from 'blossoms of coconut' in Florida (Hodges, 1962), here *A. rileyi* is reported from coconut inflorescence for the first time.

***Erechthias minuscula* (Walsingham) (Tineidae, Erechthiinae)**

Erechthias minuscula was described from Jamaica, the Virgin Islands and Grenada (Walsingham, 1897), and it is known from various Caribbean Islands (Clarke, 1971, 1986; specimens in the BMNH), North America (MPGNA, 2012), Africa, southern Asia and the Pacific (Lepesme, 1947; Clarke, 1971; Zimmerman, 1978; Clarke, 1986). Meyrick (1915b, p. 367) considered that it is probably Oriental in origin, and therefore introduced in Africa, the Americas and Pacific. It is predominantly a detritus feeder found associated with dead or decaying tissue of a wide range of plants from many families (Swezey, 1909, 1910; Lepesme, 1947; Clarke, 1971; Zimmerman, 1978; Plumbley & Rees, 1983; Clarke, 1986; material in

BMNH), including coconut (Lepesme, 1947; material in BMNH from Fiji and the Solomon Islands). It is also recorded as a predator or scavenger of scale insects, especially *Pseudaulacaspis pentagona* (Targioni-Tozzetti), *Lepidosaphes pinnaeformis* (Bouché), *Icerya purchasi* Maskell, *Aspidoproctus bouvieri* Vayssière, *and Orthezia insignis* Browne (Swezey, 1909; Lepesme, 1947). In contrast to all other reports, Harris (1935) stated that 'there is no doubt as to its ability to feed on living coconut tissues' in Tanzania, but this has not been confirmed.

A related species, *E. flavistriata* (Walsingham) found from South-East Asia and the Pacific, has been recorded from coconut flowers (Meyrick, 1928), but is primarily associated with leaf sheaths, dead leaves and fibrous parts from a variety of plants, but in particular sugar cane (Zimmermann, 1978).

Xystrologa nigrivitta (Walsingham) (Tineidae, ?Meesiinae)

The following is based on a recent paper on the West Indian species of *Xystrologa* by Davis *et al.* (2012). This Neotropical genus comprises six described and several undescribed species. Two species occur in the West Indies: *X. grenadella* (Walsingham) and *X. nigrivatta*. The former has been reared from branches of *Sabal causiarum* (Arecaceae) in Bermuda, from bark mulch used as a potting media and roots of orchids in nurseries in Florida, from damaged areas on the trunks of bonsai *Ficus* trees in Florida, on the roots of pineapple in Puerto Rico, and pupae have been found under bark of an unidentified tree in Dominica. As an introduced species in Germany, it was recently reared from caterpillars 'found in dead wet wood of *Robinia*, on which are arranged *Tillandsia* and other Bromeliaceae, and on palm (*Washingtonia* sp.)' in a large greenhouse.

Xystrologa nigrovitta has been reared from an unidentified bracket fungus in Dominica, but has not previously been associated with a palm inflorescence. Thus, the available records point to members of this genus being opportunistic detritivores. *Xystrologa nigrovitta* is known from several West Indian Islands, including Trinidad, and it probably occurs throughout the West Indies. It was reared from the inflorescence of *Roystonea oleracea* in the survey reported below.

Other species

Lepesme (1947) includes a record of *Tirathaba complexa* (Butler) (=*Harpagoneura complexa*) (Pyralidae, Galleriinae) from Brazil. This is one of several species names included under the common name coconut spike moth, but it is unclear whether this includes several similar species or one variable species under the general name *T. rufivena* (Walker) (Waterhouse & Norris, 1987). This species or group of species from South-East Asia and the Pacific is considered a pest of coconut inflorescence, although the impact on yield is questionable (Corbett, 1931; Taylor, 1930; Cock *et al.*, 1987; Waterhouse & Norris, 1987). However, the record from Brazil is likely to be an error or misidentification, as there have been no subsequent observations of this relatively conspicuous inflorescence feeder from South America.

Additional species recorded below, for which there is no published information include a species of Gelechiidae reared from *Attalea maripa* and two species of Cosmopterigidae reared from *A. maripa* and *Mauritia flexuosa*.

Results: Field survey and lab work in Trinidad

More than one thousand moths of 12 species were reared from six of the 14 palm species (Table 4). Moths emerged from the samples for up to two months after collection of the inflorescence sample (Fig. 1).

Atheloca bondari Heinrich (Pyralidae, Phycitinae) (Fig. 2a)

Adults of *A. bondari* were identified as an *Atheloca* sp. from the photographs on MPGNA (2012), and to species from Heinrich (1956). The Trinidad specimens have the strong hair tuft at the base of the hind leg tibia, which is the distinguishing character for *A. bondari*, and absent in *A. subrufella* (Heinrich, 1956). Accordingly, this species is treated as *A. bondari*, although it is recognised that this may prove to be a synonym of *A. subrufella* (see literature review).

This species was reared from *Roystonea oleracea* at Kernahan, Nariva Swamp. The caterpillars were characterised as having a dark brown head and pronotum, purple-brown body with paler dorsal and lateral lines (Fig. 4), but these preliminary observations need confirmation based on systematic rearing of documented individual caterpillars. Caterpillars were observed to make webbing amongst flowers, tie together dead flowers, and feed amongst the fluffy padding of *R. oleracea* inflorescences and on male flowers. Caterpillars are larger than those of *Batrachedra nuciferae* and produce correspondingly larger frass.

Similar caterpillars were found on coconut at Curepe, but none were individually reared successfully

Table 4. Summary of moths reared from palm inflorescences. No moths were reared from *Adonidia merrillii* (Curepe, CABI), *Bactris major* (Bush Bush Island, Botanic Gardens), *Bactris simplicifrons* (Bush Bush Island), *Calamus* sp. (Botanic Gardens), *Euterpe precatoria* (Aripo Savannah), *Licuala spinosa* (Botanic Gardens), *Ptychosperma macarthurii* (Curepe, CABI; Botanic Gardens), or *Syagrus romanzoffiana* (Botanic Gardens). In addition, a single specimen of *Phidotricha erigens* was reared from the young male inflorescence of *Mauritia flexuosa*.

Palm species	Location	*Atheloca bondari*	*Neodavisia sp.*	*Batrachedra nuciferae*	*Batrachedra sp.*	*Holcocera sp(p).*	*Anatrachyntis rileyi*	*Erechthias minuscula*	*Xystrologa nigrivitta*	Unidentified Gelechiidae	Unidentified Cosmopterigidae 1	Unidentified Cosmopterigidae 2	Total
Attalea maripa (old male)	Bush Bush Is. (North)		26							11	21		58
Cocos nucifera (combined)	Curepe, CABI			40		10	15	1					66
Cocos nucifera	Centeno			20			1	1					22
Cocos nucifera (combined)	Waller Field			121			116	7					244
Cocos nucifera	Bush Bush Is. (North)			1									1
Cocos nucifera	Kernahan	1		26									27
Mauritia flexuosa (old male)	Aripo Savannah											52	52
Mauritia flexuosa (young male)	Aripo Savannah					8	1						9
*Pritchardia pacifica**	Botanic Gardens						16	3					19
Roystonea oleracea	Kernahan	10		57		16	41	339	135				598
Roystonea oleracea	Botanic Gardens						2	2					4
Sabal mauritiformis	Kernahan				12								12
TOTAL		11	26	265	12	34	192	353	135	11	21	52	1,112

* Introduced ornamental species.

to confirm the identification. One adult was reared from a caterpillar isolated from coconut at Kernahan; amongst the terminal male flowers of one secondary inflorescence branch, it had tied three dead male flowers to the branch with silk. Since *A. bondari* is reported to attack coconut inflorescences (Bondar, 1940a, 1940b; Heinrich, 1956) it seems safe to anticipate that this species does attack coconut more widely in Trinidad, although not as frequently as some of the other species considered here, such as *B. nuciferae*. Furthermore, as noted by Bondar (1940a, 1940b), the caterpillar is more damaging than that of *B. nuciferae*, causing direct damage to male and female flowers.

Cocoons are formed completely enclosed in loose debris, but were not distinguished from those of *Anatrachyntis rileyi*. The adult moths are typical phycitine moths (Fig. 2a), and no other members of this subfamily were obtained in our survey.

Phidotricha erigens (Ragonot) (Pyralidae, Epipaschiinae) (Fig. 2b)

This species (Fig. 2b) was reared just once from old, dead male inflorescence of *Mauritia flexuosa*. Given the range of alternative hosts reported, it is probably an occasional facultative herbivore or detritivore in palm inflorescences.

Neodavisia sp. (Pyralidae, Pyralinae) (Fig. 2c)

This appears to be an undescribed species, probably in the genus *Neodavisia* (Fig. 2c); it will be

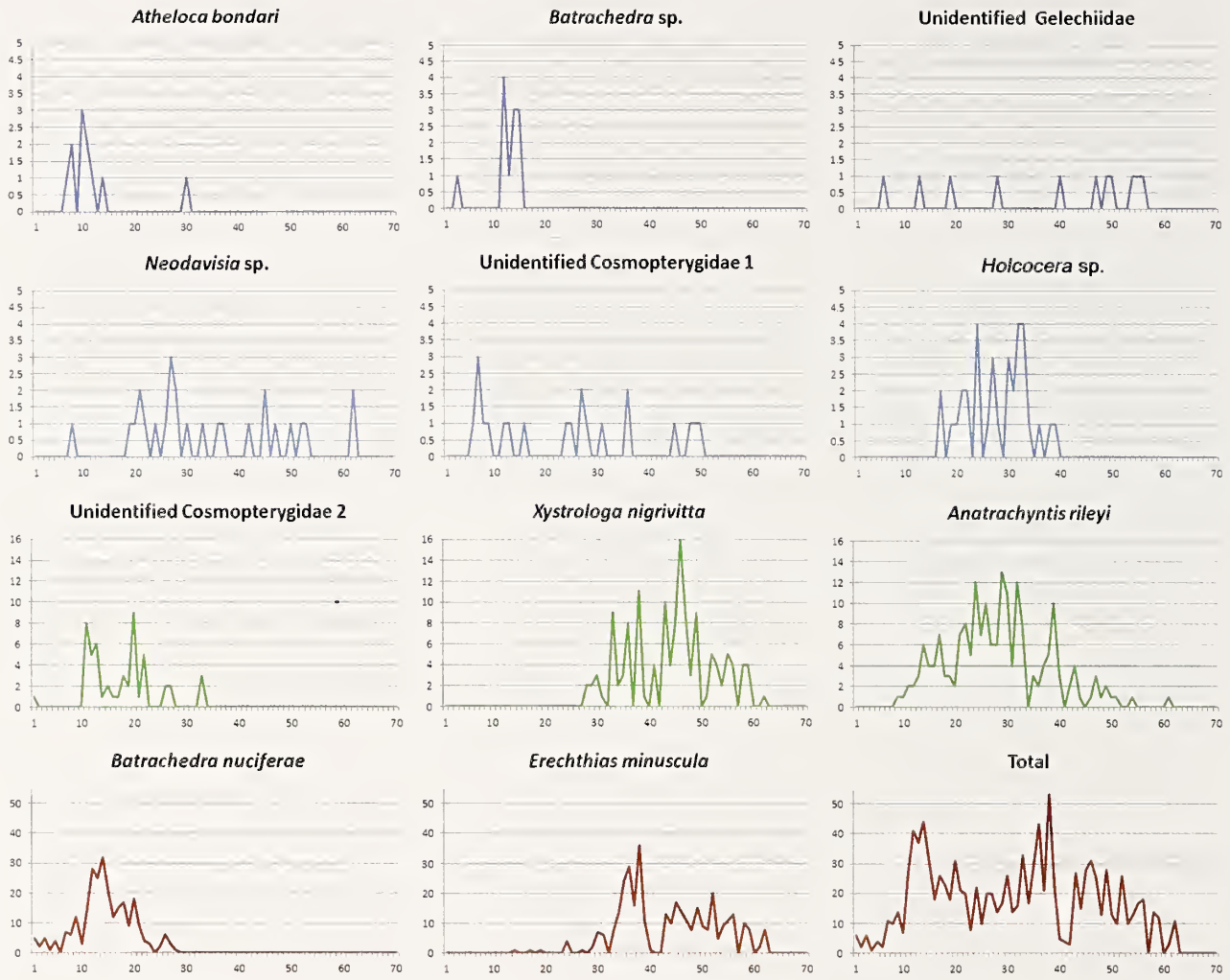

Figure 1. Number of moths emerging daily, counting from the day of sample collection. Results are pooled for all collections. Each colour line is related to a different axis scale. The single specimen of *Phidotricha erigens* is not shown; it emerged 27 days after the inflorescence was collected.

described in a forthcoming paper dealing with this and two similar, perhaps synonymous, genera from the Americas (M.A. Solis, pers. comm., 2012). It was reared from the dead male inflorescence of *Attalea maripa* and associated with dark caterpillars similar to those of *Atheloca bondari* and *Xystrologa nigrivitta* feeding amongst the stamens, and cocoons spun up amongst and completely covered by the stamens. Because the inflorescence was old and dead, most likely the caterpillars feed on dead plant material.

Batrachedra nuciferae Hodges (Batrachedridae) (Figs. 2d, 3b)

Cock (2013) reports observations on *B. nuciferae* from this survey, and illustrates the early stages. Caterpillars were found on coconut and *Roystonea oleracea*, but not on other palms; they were considered to be primarily restricted to the male flowers in which they are pollen feeders.

Batrachedra sp. unidentified (Batrachedridae) (Fig. 2e)

This species was reared from carat palm, *Sabal mauritiiformis*, at Kernahan, Nariva Swamp. It resembles *B. nuciferae*, but is significantly smaller (Fig. 2d). Examination of parts of the inflorescence that included open flowers revealed webbing and frass, forming a protective tunnel or tube on the stem (Fig. 5). At one end this tunnel covered a shallow groove in the inflorescence branch, and the webbing here incorporated yellow debris from the branch in a more

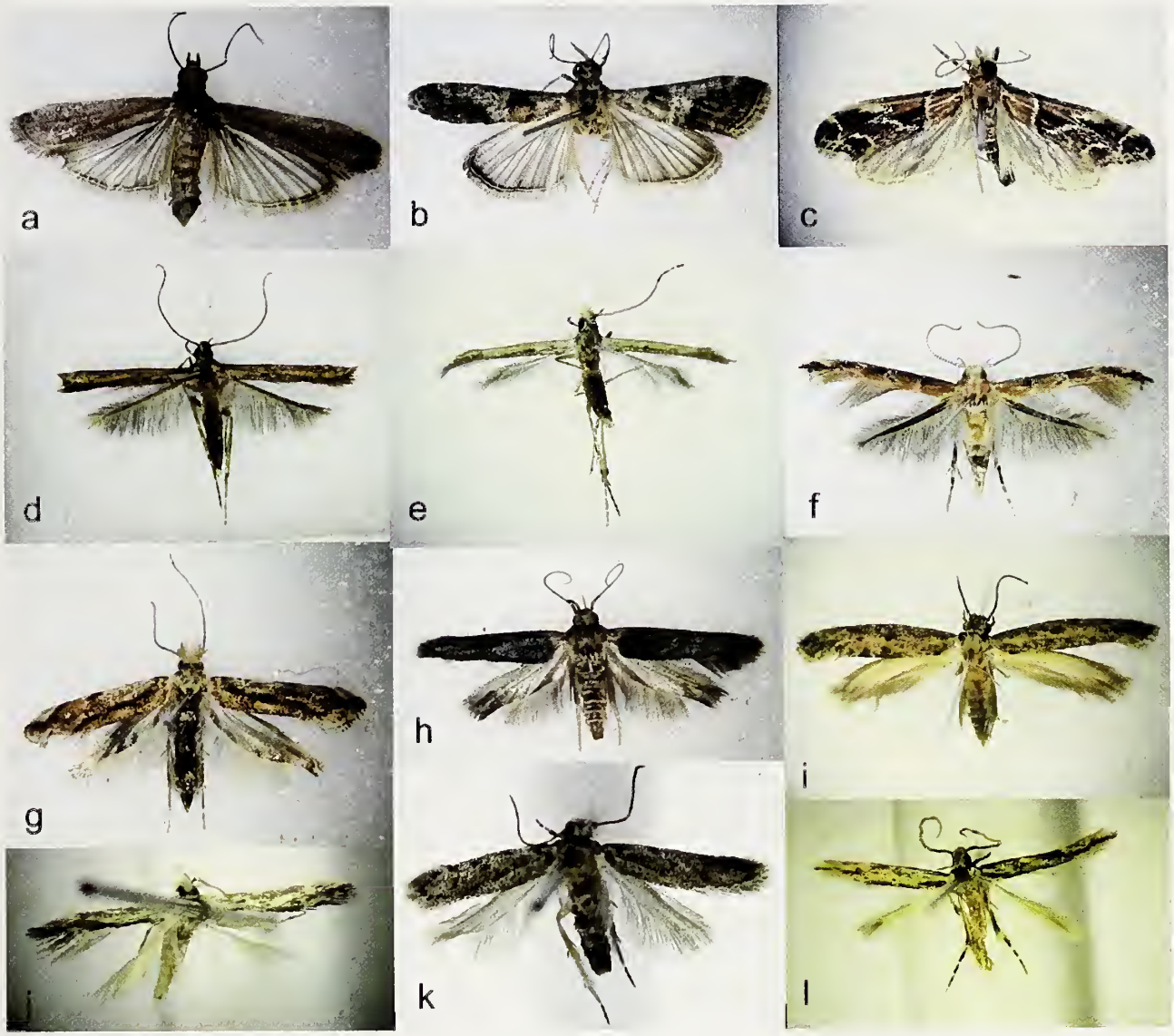

Figure 2. Pinned moths reared from palm inflorescences, Trinidad, Oct 2011; not to scale, the wingspan for each is given; **a**, *Atheloca bondari*, male, 16.6mm; **b**, ***Phidotricha erigens***, 9.7mm; **c**, *Neodavisia* sp., 10.5mm; **d**, *Batrachedra nuciferae*, 10mm; **e**, *Batrachedra* sp. indet. reared from *Sabal mauritiiformis*, 7mm; **f**, *Anatrachyntis rileyi*, 9mm; **g**, *Erechthias minuscula* female, 9.7mm; **h**, *Holcocera* sp., 13.7mm; **i**, *Xystrologa nigrivitta* female, 8.0mm; **j**, unidentified Cosmopterigidae sp. 2 (from *Mauritia flexuosa*), 5.2mm.; **k**, unidentified Gelechiidae (from *Attalea maripa*), 8.9mm; **l**, unidentified Cosmopterigidae sp. 1 (from *Attalea maripa*), 5.5mm

or less continuous cover or shelter. The remainder of the tunnel was more transparent, with scattered frass incorporated. Each tunnel sheltered a small pale caterpillar, resembling those of *B. nuciferae*, but smaller and with the head and pronotum pale brown. These caterpillars bore into the base of individual flowers and move from flower to flower, mostly in their tunnels. In due course some of these caterpillars made cocoons in the style of *B. nuciferae*, but smaller. The adult is similar to that of *B. nuciferae* (fig. 2d) but smaller. Three adults were reared from these caterpillars and a further nine by emergence box over two weeks.

Holcocera sp. (Meyrick) (Blastobasidae, Holcocerinae) (Fig. 2h)

A *Holcocera* sp. was reared in this survey from inflorescences of three palm species: coconut, *Roystonea oleracea* and dead male inflorescence of

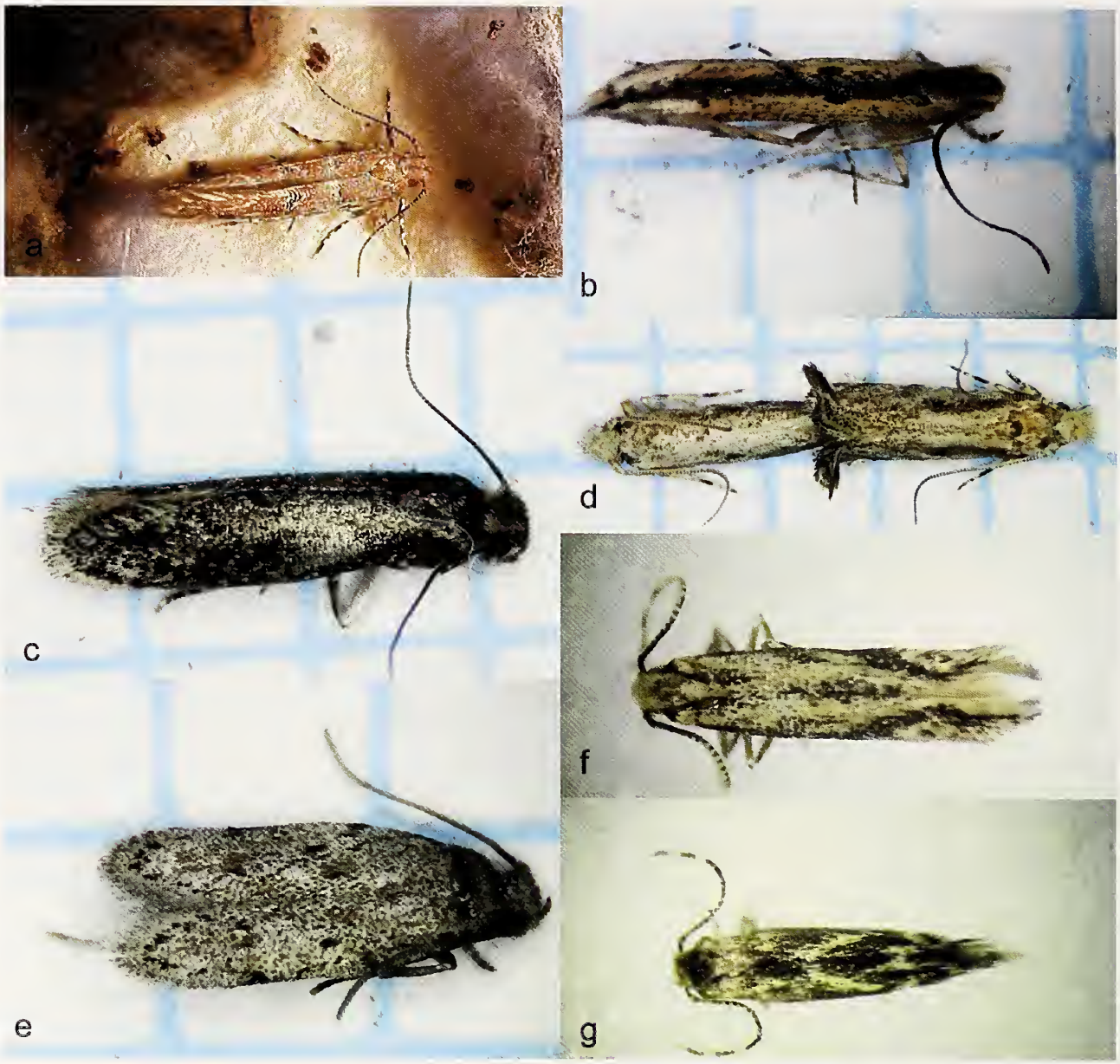

Figure 3. Dead moths (except for photo a, which was alive) in more or less normal resting positions, reared from palm inflorescences, Trinidad, Oct 2011; not to scale, see legend to Figure 2 for wingspans; scale squares = 2mm. **a**, living *Anatrachyntis rileyi*; **b**, *Batrachedra nuciferae*; **c**, *Xystrologa nigrivitta*; **d**, *Erechthias minuscula* mating pair; **e**, unidentified Gelechiidae (from *Attalea maripa*); **f**, unidentified Cosmopterigidae sp. 1 (from *Attalea maripa*); **g**, unidentified Cosmopterigidae sp. 2 (from *Mauritia flexuosa*). Figure a (from MALMR 2008), photo by Research Division Central Experimental Station, Centeno, Trinidad and Tobago.

Mauritia flexuosa. Specimens were identified as an unknown *Holcocera* sp. by D. Adamski, United States Department of Agriculture. The first author examined the male genitalia of a specimen from each palm and considered them to represent just one species, closely related to, but apparently distinct from, *H. ocrobathra*, the species described from coconut flowers in Guyana, and *H. grenadensis*, described from Grenada and Dominica (see literature review).

Caterpillars of this species were found on and reared from amongst the fluffy matrix and dead male flowers of *R. oleracea* at Kernahan, but we did not establish which part of this served as their food source. They were characterised as similar to those

of *Atheloca bondari* (Fig. 4) but darker. *Holcocera* spp. generally feed on detritus and dead plant material, and this is probably the role of this species in palm inflorescences. The cocoons were not distinguished from those of *A. bondari*. The adults (Fig. 2h) are easily distinguished from the other species obtained in this survey by their wing shape and colour.

Anatrachyntis rileyi (Walsingham) (Cosmopterigidae) (Figs. 2f, 3a)

This species was initially identified by comparison with the type and the BMNH series. All specimens were checked against the diagnostic features in Hodges (1978, p. 47), to ensure that no *A. badia* were present. A subsample of pinned moths was examined by D.R. Davis, Smithsonian Institution, who confirmed their identity. The adult of this moth (Fig. 3a) was illustrated incorrectly as *Batrachedra nuciferae* in MALMR (2008). It is attractively coloured and marked in tones of orange and brown (Figs. 2f, 3a) and easily distinguished amongst the moths reared from the survey.

In this survey, *A. rileyi* was reared from the inflorescences of five palm species (Table 4). The caterpillar was characterised as having the head chestnut brown, pronotum and anal plate brown, body pink-brown (Fig. 6), but these preliminary observations need confirmation based on systematic rearing of documented individual caterpillars, an exercise beyond our resources on this occasion. The cocoon was similar to that of *Atheloca bondari*, but smaller. The exact food and feeding style was not established, but the record from dead male inflorescence of *M. flexuosa*, and the fact that adults emerged later from the emergence boxes than did those of the pollen-feeding *B. nuciferae*, supports the expectation that it feeds on dead plant material, as has been previously documented.

Erechthias minuscula (Walsingham) (Tineidae, Erechthiinae) (Figs. 2g, 3d)

This species was initially identified by comparison with the BMNH series. A subsample was examined by D.R. Davis, Smithsonian Institute, who confirmed this identification. It was obtained from Kernahan by emergence box from *Roystonea oleracea* in large numbers and once from coconut (Table 4). Amongst the material reared, it was distinctive due to the reflexed wing tips (Fig. 3d).

Early stages have not been unequivocally associated, but caterpillars found on coconut at Kernahan (Fig. 7) are likely to be this species. This caterpillar webbed

Figure 4. Caterpillar of *Atheloca bondari* amongst dropped male flowers and fluffy matrix of inflorescence of palmiste, *Roystonea oleracea*, Kernahan.

Figure 5. Caterpillars and signs of *Batrachedra* sp. indet. on carat palm, *Sabal mauritiiformis*, Kernahan. Note the webbing and frass to the right.

Figure 6. Caterpillar of *Anatrachyntis rileyi* amongst silk webbing on dropped male flowers of palmiste, *Roystonea oleracea*, Kernahan.

Figure 7. Provisionally associated early stages of *Erechthias minuscula* on coconut, Kernahan. **a**, dead male flowers attached to inflorescence with silk webbing; **b**, caterpillar, dorsolateral view.

together dead male flowers attaching them to the inflorescence branch, sometimes in a pendulous chain (Fig. 7a). One had attached a dead male flower to the base of a female flower, and although the female flower was marked, it did not appear to have been significantly damaged on this occasion. These caterpillars were characterised as having a chestnut brown head, dark brown pronotum with a narrow pale dorsal line, body dull pale brown with darker dorsal, dorsolateral and lateral longitudinal lines; body with erect setae with the base dark.

Xystrologa nigrivitta (Walsingham) (Tineidae, ?Meesiinae) (Figs. 2i, 3c)

This species was reared commonly from the inflorescence of *Roystonea oleracea* from Kernahan (Table 4). Emergence did not start until a month after the inflorescence was collected (Fig. 1). No observations were made on the early stages, but given the known biology of the genus (Davis *et al.*, 2012) they are likely to be detritivores in inflorescences of *R. oleracea*.

Unidentified Cosmopterigidae sp. 1 and Gelechiidae sp. from *Attalea maripa* (Figs. 2k, 2l, 3e, 3f)

Two more species were reared from the old dead male inflorescence of *Attalea maripa*, where they were probably feeding on dead plant material. The old male inflorescence, in which the flower parts, including the long pollen-bearing stamens, were completely dead and dry, showing a great deal of old feeding damage by Lepidoptera, based on the amount of frass and webbing that was observed (Fig. 8). The flower remains contained many small 3mm long, plain white Lepidoptera cocoons, which were associated with an unidentified Cosmopterigidae species (sp. 1, Figs. 2l, 3f) obtained by emergence box. An unidentified species of Gelechiidae (Figs. 2k, 3e) was obtained by emergence box only. The relative contribution of the different species reared to the damage observed is not clear. Although no other distinctive remains in terms of cocoons were found when examining the inflorescence, it is possible that additional species may have completed development and emerged and dispersed before our sample was taken.

In addition to these small species, a long, tough silk-lined gallery or tunnel was found running through the dry mass of stamens, more than 30cm long and in places 1cm in diameter (Fig. 9). A cast head capsule, 2.4mm wide x 2.7mm high, was found in this gallery. No other sign of the caterpillar or its pupa were found, but we assume it was the maker of this tunnel. The purpose of the tunnel and life style of the

caterpillar that made it is open to speculation. The tunnel would probably provide protection from small vertebrate predators that are likely to be attracted to the large number of caterpillars in the inflorescence. It would enable the inhabitant to move around safely over long distances within the inflorescence; could the builder be a predator itself?

Unidentified Cosmopterigidae sp. 2 from *Mauritia flexuosa* (Figs. 2j, 3g)

Some feeding damage and very small caterpillars were found under the bracts of the old male inflorescence of *Mauritia flexuosa*. More than 50 moths of a very small unidentified Cosmopterigidae species (sp. 2, Figs. 2j, 3g) were subsequently reared by emergence box from the old male inflorescence, but not from the young inflorescence sampled from the same palm. We suppose that caterpillars of this species feed as detritivores on dead plant tissue in the old inflorescence.

Discussion and conclusions

In total, more than one thousand moths of 12 species were reared from six of the 14 palm species sampled (Table 4). All the previously reported genera of palm-feeding Lepidoptera were obtained apart from *Cadra*. Although *C. cautella* has been recorded from Trinidad (Kaye & Lamont, 1927), this species was not found in the survey. Given the observations of Bondar (1940a, 1940b), it seems likely that further surveys will show that one or more *Cadra* spp. develop in palm inflorescences in Trinidad.

Of the moths reared, three could not be identified beyond family, three could only be identified to genus, and the remaining six were identified to species. These six comprise two species associated with coconut (*Atheloca bondari*, *Batrachedra nuciferae*) and four that are polyphagous and widespread (*Xystrologa nigrivitta*, *Anatrachyntis rileyi*, *Erechthias minuscula*, *Phidotricha erigens*). Of these, *P. erigens* has long been known from Trinidad (Kaye & Lamont, 1927), *B. nuciferae* was reported recently (MALMR, 2006, 2008), and *X. nigrivitta* was reported from Trinidad only after the survey was completed (Davis *et al.*, 2012). The remaining species (*Atheloca bondari*, *Anatrachyntis rileyi*, *E. minuscula* and the partially identified species) have not previously been reported from the island. This supports the suggestion of Cock (2003) that a large number of species from the families of smaller moths remain to be identified from Trinidad, and that surveys of specialist niches will rapidly generate new information on these.

Figure 8. Views of old male inflorescence of *Attalea maripa*, from Bush Bush Island showing Lepidoptera frass, and stamen remains held together with silk webbing.

Anatrachyntis rileyi and *E. minuscula* are considered to be of Old World origin and so must have been introduced with trade, probably long ago. *Batrachedra nuciferae* was suspected to be an introduced species spreading in South America (MALMR, 2006, 2008), but Cock (2013) suggests it is more likely to be an indigenous species that has been overlooked. The remaining species, including those only identified to genus and family are likely to be indigenous species, not previously reported.

Some of the moths appear to be specialists associated with particular palm species, while others are generalists. Those thought to feed on living tissue (*Atheloca bondari*, *Batrachedra* spp.) are relatively specialised on two species. Those thought to be detritivores appear to be a mixture of specialists (*X. nigrivitta* on *Roystonea oleracea*,

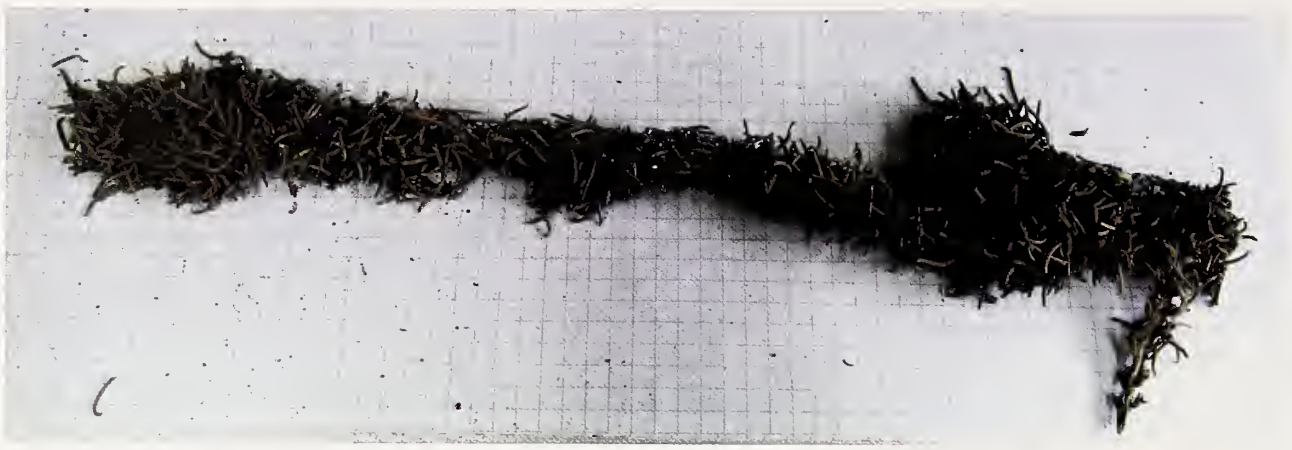

Figure 9. Half of the 'tunnel' made by an unidentified Lepidoptera species found amongst the old male inflorescence of cocorite, *Attalea maripa*, Bush Bush Island. Scale squares = 4mm.

unidentified Gelechiidae species and unidentified Cosmopterigidae sp. 1 on *Attalea maripa*, unidentified Cosmopterigidae sp. 2 on *Mauritia flexuosa*) and generalists (*Holcocera* sp., *Anatrachyntis rileyi*, and *E. minuscula*, each on several palms). However, *X. nigrivitta* has been reared from a bracket fungus (Davis *et al.*, 2012), so it is not a specialist as this survey suggested, and this also may prove to be the case when more is known about the three unidentified species.

There were three different patterns for the delay of emergence of moths from the collection date for the samples (Fig. 1). *Atheloca bondari*, the two *Batrachedra* spp. and unidentified Cosmopterigidae sp. 2 (from old *M. flexuosa*) all emerged within the first month; the unidentified Gelechiidae species, unidentified Cosmopterigidae sp. 2 and *Neodavisia* sp. (all from dead *Attalea maripa*) emerged at a fairly steady, low rate over two months; and *Holcocera* sp., *X. nigrivitta*, *Anatrachyntis rileyi*, and *E. minuscula* emerged primarily in the second month after the emergence boxes were set up. We suggest these patterns represent two different life styles. The first group, those species feeding on fresh plant material, rapidly completed their development and emerged within a month, whereas the last group, developing as detritivores, completed their development more slowly, either because they started later or because the poorer food quality dictated slower development, and emerged after the plant-feeding species. The middle group also are detritivores, reared from dead inflorescences of *Attalea maripa and M. flexuosa*, but because the sample of inflorescence was already dead, the moths had completed development and started to emerge immediately after collection.

Acknowledgements

The first author was responsible for the design of this work, literature review and writing; both authors (and collaborators) carried out the field work and initial laboratory work; the second author was responsible for the bulk of the laboratory work, including sorting, recording and preparation of the reared moths.

We thank the following for support and help with aspects of this study: Ms Velda Ferguson-Dewsbury, Mr Farzan Hosein, Ms Petal Ram and staff of the Forestry Department and Royal Botanic Gardens, Ministry of Food Production, Land & Marine Affairs of Trinidad & Tobago; Dr Elizabeth S Johnson, Ms Suzy Wood, CABI; Dr Yasmin Comeau and Mr Winston Johnson, National Herbarium; Mr Imran Gaffoor of Waller Field, Trinidad and Tobago; Dr M Alma Solis, Dr John W Brown and Dr David Adamski, United States Department of Agriculture, Systematic Entomology Laboratory; Dr Don R. Davis, Smithsonian Institution.

Live and dead insect material was exported under permit from the Plant Protection Organisation of Trinidad and Tobago. Live material was imported to the UK and held in CABI's UK quarantine facility for emergence under licence from the Department for Environment, Food and Rural Affairs. The field visits to Nariva Swamp and Aripo Savannah were made under permit from the Forestry Department, Trinidad and Tobago. This study was undertaken on behalf of the Ministry of Food Production, Land & Marine Affairs of Trinidad and Tobago, in support of their role in a United Nations Environment Programme – Global Environment Facility funded project: "*Mitigating the Treats of Invasive Alien Species in the Insular Caribbean*" Project Number GFL/ 2328–2713-4A86 (PMS: GF/1030-09-03), which provided the financial support. CABI's support in Trinidad and the preparation of this paper was funded by the CABI Development Fund, with contributions from the Australian Centre for International Agricultural Research, the UK's Department for International Development and the Swiss Agency for Development and Cooperation.

Literature cited

Adamski, D. 1998. On the identity of *Holcocera guilandinae* (Busck 1900) (Lepidoptera: Gelechioidea: Coleophoridae: Blastobasinae). Proceedings of the Entomological Society of Washington 100: 731–741.

Adamski. D. 2002a. Holcocerini of Costa Rica (Lepidoptera: Gelechioidea: Coleophoridae: Blastobasinae). Memoirs of the Entomological Society of Washington 24: 147 pp.

Adamski, D. 2002b. A synopsis of described Neotropical Blastobasinae (Lepidoptera–Gelechioidea–Coleophoridae). Thomas Say Publications in Entomology: Monographs. Entomological Society of America, Lanham, Maryland, 150 pp.

Adamski, D. 2013. Review of the Blastobasinae of Costa Rica (Lepidoptera: Gelechioidea: Blastobasidae). Zootaxa 3618(1): 1–223.

Adamski, D. & R.L. Brown. 1989. Morphology and systematics of North American Blastobasidae (Lepidoptera: Gelechioidea). Mississippi Agricultural and Forestry Experiment Station Technical Bulletin 165: 1–70.

Adamski, D., J.W. Brown & W.H. White. 2006. Description of the immature stages of *Pyroderces badia* (Hodges) (Lepidoptera: Cosmopterigidae), with a new host record from Louisiana. Proceedings of the Entomological Society of Washington 108: 341–346.

Adamski, D., R.S. Copeland, S.E. Miller, P.D.N. Hebert, K. Darrow & Q. Luke. 2010. A review of African Blastobasinae (Lepidoptera: Gelechioidea: Coleophoridae), with new taxa reared from native fruits in Kenya. Smithsonian Contributions to Zoology 630, vi + 68 pp.

Arnal, E.; J. Clavijo, E. Soto & F. Ramos. 1998. *Batrachedra nuciferae* Hodges, 1966 (Lepidoptera: Momphidae) a new pest of coconut in Venezuela. Boletin de Entomologia Venezolana, Serie Monografias 13: 69–71.

Barfod, A.S., T. Burholt & F. Borchsenius. 2003. Contrasting pollination modes in three species of *Licuala* (Arecaceae: Coryphoideae). Telopea 10: 207–223.

Beccaloni, G.W., M.J. Scoble, G.S. Robinson & B. Pitkin (eds.) 2003. The Global Lepidoptera Names Index (LepIndex). http://www.nhm.ac.uk/entomology/lepindex (last accessed 1 November 2011).

Becker, V.O. 1984. 24. Coleophoridae, pp. 42–43. *In*: Heppner, J.B. (ed.), Atlas of Neotropical Lepidoptera. Checklist: Part 1 Micropterigoidea – Immoidea. Dr W Junk Publishers, The Hague, Netherlands.

Bento, J.M.S., D.E. Nava, M.C.M. Chagas & A.H. Costa. 2006. Biology and mating behavior of the coconut moth *Atheloca subrufella* (Lep.: Phycitidae). Florida Entomologist 89: 199–203.

Bodkin, G.E. 1922. Government economic biologist. Report of the Department of Science & Agriculture, British Guiana 1920: 51–58. [*Review of Applied Entomology* 1922 10: 561].

Bondar, G. 1940a. Insetos nocivos e moléstias do coqueiro (*Cocos nucifera*) no Brasil. Tipographía Naval, Brasil, 160 pp.

Bondar, G. 1940b. Notas entomológicas da Bahia. Revista de Entomologia, Rio de Janeiro 11: 199–214.

Brown, J.W., D. Adamski, R.W. Hodges, & S.M. Bahr II. 2004. Catalog of the type specimens of Gelechioidea (Lepidoptera) in the collection of the National Museum of Natural History, Smithsonian Institution, Washington, DC. Zootaxa 510: 1–160.

Busck, A. 1917. The pink bollworm, *Pectinophora gossypiella*. Journal of Agricultural Research 9: 343–370, plates 7–12.

Carneiro, J.S., P.H.S. da Silva, C.C.P. Nogueira & H.U. de Sousa. 2004. Morfologia externa, biologia, danos e sugestões de controle da traça-dos-frutos-docoqueiro *Batrachedra nuciferae*. Comunicado Técnico, Ministério da Agricultura Pecuária e Abasticimento, (Teresina, PI, Brazil) 159: 4 pp.

Carregaro, J.B. 2007. Insetos herbívoras im botões florais de *Caryocar brasiliense* Camb (Caryocaraceae): comparação entre duas áreas de cerrado de Brasilia, D.F. MSc thesis, Universidade de Brasilia, v + 35 pp.

Child, R. 1974. Coconuts. 2nd ed. Longmans, Green & Co., London, xvi + 335pp.

Clarke, J.F.G. 1963. Catalogue of the type specimens of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick. Vol. 4: Phalonidae, Carposinidae, Chlidanotidae, Oecophoridae, Blastobasidae, Momphidae, Epermeniidae, Strepsimanidae, Physoptilidae. The Trustees of the British Museum, London, 521 pp.

Clarke, J.F.G. 1971. The Lepidoptera of Rapa Island. Smithsonian Contributions to Zoology 56: 282 pp.

Clarke, J.F.G. 1986. Pyralidae and Microlepidoptera of the Marquesas Archipelago. Smithsonian Contributions to Zoology 416: 485 pp.

Cock, M.J.W. 2003. On the number of species of moths (Lepidoptera) in Trinidad and Tobago. Living World, Journal of the Trinidad and Tobago Field Naturalists' Club 2003: 49–58.

Cock, M.J.W. in press. *Batrachedra nuciferae*, an inflorescence-feeding moth associated with coconut, *Cocos nucifera*, and palmiste, *Roystonea oleracea*, in Trinidad, West Indies. Journal of Insect Science.

Cock, M.J.W., C.N. Gallego & H.C.J. Godfray. 1987. Biological control of *Tirathaba rufivena* in the Philippines, pp. 147–157. *In*: Ferrar, P. & D.-H. Stechmann (eds.), Biological control in the South Pacific. Report on an International Workshop held at Government Experimental Farm, Vaini, Kingdom of Tonga, 17-25 October 1985. Ministry of Agriculture, Fisheries & Forests of Tonga, Nuku'alofa, Tonga.

Comeau, P.L., Y.S. Comeau & W. Johnson. 2003. The palm book of Trinidad and Tobago including the Lesser Antilles. The International Palm Society, 108 pp.

Corbett, G.H. 1922. Moths from coconut spikes. Malayan Agricultural Journal 10: 184–185.

Corbett, G.H. 1931. The control and economic importance of the greater spike moth (*Tirathaba rufivena* Walk.). Department of Agriculture of the Straits Settlements and Federated Malay States, Scientific Series 8: 1–14.

Corbett, G.H. & B.A.R. Gater. 1924. *Batrachedra arenosella*. Walk., (Cosmopterygidae) in relation to the nut-fall of coconuts. Malayan Agricultural Journal 12: 115–122.

Davis, D.R., M.M. Davis & C. Mannion. 2012. Neotropical Tineidae IX: A review of the West Indian *Xystrologa* and biology of *Xystrologa grenadella* (Wlsm.), an invasive pest of cultivated greenhouse plants in southern Florida, USA and Germany (Lepidoptera: Tineoidea). Proceedings of the Entomological Society of Washington 114: 439–455.

Diniz, I.R. & H.C. Morais. 2002. Local pattern of host plant utilization by lepidopteran larvae in the cerrado vegetation. Entomotropica 17: 115–119.

Dransfield, J., N.W. Uhl, C.B., Asmussen, W.J. Baker, M.M. Harley & C.E. Lewis. 2008. Genera Palmarum - The evolution and classification of palms. Kew Publishing, Kew, UK, 744 pp.

Ervig, F. 1993. Notes on the phenology and pollination of the dioecious palms *Mauritia flexuosa* (Calamoideae) and *Aphandra natalia* (Phytelephantoideae) in Ecuador, pp. 7–12. *In*: Barthlott W., C. Naumann, C. Schmidt-Loske & K. Schuchmann (eds.), Animal-plant interactions in tropical environments. Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Germany.

Essig, F.B. 1971. Observations on pollination in *Bactris*. Principes 15: 20–24.

Garraway, E., D.C. Henry & B.R. Critchley. 2007. The biology, ecology and economic importance of the pink scavenger caterpillar *Pyroderces rileyi* (Lepidoptera: Cosmopterigidae) on banana in Jamaica. Tropical Science 47: 231–243.

Goater, B. 1986. British pyralid moths. A guide to their identification. Harley Books, Colchester, UK, 175 pp.

Habeck, D.H. & J.C. Nickerson. 1982. *Atheloca subrufella* (Hulst), a pest of coconuts (Lepidoptera: Pyralidae: Phycitinae).

Entomology Circular No. 241. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, 2 pp.

Hajibabaei, M., G.A.C. Singer, P.D.N. Hebert & D.A. Hickey. 2007. DNA barcoding: how it complements taxonomy, molecular genetics and population genetics. Trends in Genetics 23: 167–172.

Harris, W.V. 1935. Report of the assistant entomologist, 1934. Report. Department of Agriculture, Tanganyika 1935: 84–89.

Heckford, R.J. & P.H. Sterling. 2004. *Anatrachyntis badia* (Hodges, 1962) (Lepidoptera: Cosmopterigidae) an adventive species new to the British Isles, possibly the second record from Spain and a larval description. Entomologist's Gazette 55: 81–89.

Heinrich, C. 1921. Some Lepidoptera likely to be confused with the pink bollworm. Journal of Agricultural Research 20: 807–836, plates 93–109.

Heinrich, C. 1956. American moths of the family Phycitinae. United States National Museum Bulletin 207: viii + 581 pp.

Henderson, A. 1986. A review of pollination studies in the Palmae. Botanical Review 52: 221–259.

Henderson, A., G. Galeano & R. Bernal. 1995. Field guide to the palms of the Americas. Princeton University Press, Princeton, New Jersey, USA, ix + 353 pp. + 64 plates.

Heppner, J.B. 2003. Lepidoptera of Florida. Part 1 Introduction and catalog. Arthropods of Florida and Neighboring Land Areas Volume 17. Florida Department of Agriculture & Consumer Services, Gainesville, Florida, USA, x + 670pp.

Hodges, R.W. 1962. A revision of the Cosmopterigidae of America north of Mexico, with a definition of the Momphidae and Walshiidae (Lepidoptera: Gelechioidea). Entomologica Americana 42 (n.s.): 166 pp, 199 figs.

Hodges, R.W. 1966. Review of the New World species of *Batrachedra* with description of three new genera (Lepidoptera: Gelechioidea). Transactions of the American Entomological Society 92: 585–651.

Hodges, R.W. 1978. Moths of America North of Mexico, Fascicle 6.1: Walshiidae and Cosmopterigidae. E.W. Classey Ltd. and Wedge Entomological Research Foundation, London, 166 pp.

Hodges, R.W. 1999. 9. The Gelechioidea, pp. 131–158. *In*: Kristensen, N.P. (ed.), Lepidoptera, moths and butterflies. Volume 1: Evolution, systematics, and biogeography. Walter de Gruyter, Berlin, Germany.

Hodges, R.W. *et al.* (eds.) 1983. Checklist of the Lepidoptera of North America north of Mexico. E. W. Classey, London, xxiv + 284 pp.

Howard, F.W.; D. Moore, R.M. Giblin-Davis & R.G. Abad. 2001. Insects on palms. CABI Publishing, Wallingford, Oxon, UK, 400 pp.

Janzen, D.H., W. Hallwachs, P. Blandin, J.M. Burns, J.-M. Cadiou, I. Chacon, T. Dapkey, A.R. Deans, M.E. Epstein, B. Espinoza, J.G. Franclemont, W.A. Haber, M. Hajibabaei,; J.P.W. Hall, P.D.N. Hebert, I.D. Gauld, D.J. Harvey, A. Hausmann, I.J. Kitching, D. Lafontaine, J.-F. Landry, C. Lemaire, J.Y. Miller, J.S. Miller, L. Miller, S.E. Miller, J. Montero, E. Munroe, S.R. Green, S. Ratnasingham, J.E. Rawlins, R.K. Robbins, J.J. Rodriguez, R. Rougerie, M.J. Sharkey, M.A. Smith, M.A. Solis, J.B. Sullivan, P. Thiaucourt, D.B. Wahl, S.J. Weller, J.B. Whitfield, K.R. Willmott, D.M. Wood, N.E. Woodley & J.J. Wilson. 2009. Integration of DNA barcoding into an ongoing inventory of complex tropical biodiversity. Molecular Ecology Resources 9 (Suppl. 1): 1–26.

Kaila, L. 2004. Phylogeny of the superfamily Gelechioidea (Lepidoptera: Ditrysia): an exemplar approach. Cladistics 20: 303–340.

Kaila, L., M. Mutanen & T. Nyman. 2011. Phylogeny of the mega-diverse Gelechioidea (Lepidoptera): Adaptations and determinants of success. Molecular Phylogenetics and Evolution 61: 801–809.

Kalshoven, L.G.E. & P.A. van den Laan. 1981. The pests of crops in Indonesia. P.T. Ichtiar Baru-Van Hoeve, Jakarta, Indonesia, 701 pp.

Kaye, W.J. & N. Lamont. 1927. A catalogue of the Trinidad Lepidoptera Heterocera (moths). Memoirs of the Department of Agriculture, Trinidad and Tobago 3: 144 pp.

Kimball, C.P. 1965. Lepidoptera of Florida. Arthropods of Florida and neighbouring land areas. Volume 1. State of Florida Department of Agriculture, Gainesville, Florida, 363 pp.

Koster, S. & S. Sinev. 2003. Momphidae, Batrachedridae, Stathmopodidae, Agonoxenidae, Cosmopterigidae, Chrysopeleiidae. Microlepidoptera of Europe (5). Apollo Books, Stenstrup, Denmark, 387 pp.

Lederer, J. 1863. Beitrag zur Kenntnis der Pyralidinen. Wiener Entomologische Monatschrift 7: 243–280, 331–378, 379–426, 427–502, plates 2–18.

Lee, S. & R.L. Brown. 2009a. Revised checklist of Coleophoridae in Neotropical Region. Updated date: 10 February 2009. http://mississippientomologicalmuseum.org.msstate.edu/Researchtaxpages/Lepidoptera/Coleophoridae/Checklists/Neotropical-Coleophoridae.html

Lee, S. & R.L. Brown. 2009b. Revised checklist of Cosmopterigidae in Neotropical Region. Updated date: 10 February 2009. http://mississippientomologicalmuseum.org.msstate.edu/Researchtaxpages/Lepidoptera/Cosmopterigidae/Checklists/Neotropical-Cosmopterigida.html

Lepesme P. 1947. Les insectes des palmiers. Paul Lechevalier, Paris, France, 909 pp.

Lever, R.J.A.W. 1938. Three moths from coconut flowers. Agricultural Journal of Fiji 9: 23.

Lever, R.J.A.W. 1979. Pests of the Coconut Palm. FAO, Rome, Italy, xiii + 190 pp.

MALMR (Ministry of Agriculture, Lands and Marine Resources) 2006. 1.1.8 Coconut moth (*Batrachedra nuciferae*), pp. 86–87. *In*: Ministry of Agriculture, Land and Marine Resources. Annual Report 2006. Ministry of Agriculture, Land and Marine Resources, Centeno, Trinidad & Tobago.

MALMR (Ministry of Agriculture, Lands and Marine Resources) 2008. "Coconut Moth" *Batrachedra nuciferae* - A New Pest of Coconuts. Coconut Moth Fact Sheet # 1. Ministry of Agriculture, Lands and Marine Resources – Entomology, Centeno, Trinidad & Tobago, 2 pp.

Meyrick, E. 1915a. Exotic Microlepidoptera. Vol. 1. Part 11. The author, Marlborough, UK, pp. 321–352.

Meyrick, E. 1915b. Exotic Microlepidoptera. Vol. 1. Part 12. The author, Marlborough, UK, pp. 353–384.

Meyrick, E. 1921. Exotic Microlepidoptera. Vol. 2. Part 15. The author, Marlborough, UK, pp. 449–480.

Meyrick, E. 1928. The micro-Lepidoptera of the "St. George" expedition. Transactions of the Entomological Society of London 76: 489–521.

Meyrick, E. 1931. Exotic Microlepidoptera. Vol. 4, Part 2. The author, Marlborough, UK, pp. 33–96.

Moore, D. 2001. Insects of palm flowers and fruits, pp. 233–266. *In*: Howard, F.W.; Moore, D., Giblin-Davis, R.M. & Abad, R.G., Insects on palms. CABI Publishing, Wallingford, Oxon, UK.

Mound, L. (ed.) 1989. Common insect pests of stored food products. Economic Series No. 15. (7th Edn). British Museum (Natural History), London, UK, pp. 68.

MPGNA (Moth Photographers Group of North America) 2012. Digital guide to moth identification. http://mothphotographersgroup.msstate.edu/MainMenu.shtml

Plumbley, R.A. & D.P. Rees. 1983. An infestation by *Araecerus fasciculatus* (Degeer) (Coleoptera: Anthribidae) and *Decadarchis minuscula* (Walsingham) (Lepidoptera: Tineidae) on stored fresh yam tubers in South-East Nigeria. Journal of Stored Products Research 19: 93–95.

Ragonot, E.-L. 1888. Untitled. [M. E.-L. Ragonot donne les diagnoses de cinq espèces nouvelles de Microlépidoptères de Porto-Rico.] Bulletin des Séances et Bulletin Bibliographique de la Société entomologique du France, Series 6, 8: cxxxviii–cxl.

Sánchez Soto, S. 2004. Morphologia, biologia e fototropisma de *Batrachedra nuciferae* Hodges (Lepidoptera: Coleophoridae). Master's Thesis, Universidade de São Paulo, Brazil, xi + 40 pp.

Sánchez-Soto, S. & O. Nakano. 2002. Ocorrência de *Batrachedra nuciferae* Hodges (Lepidoptera: Coleophoridae) no Estado de São Paulo. Neotropical Entomology 31: 657–658.

Sánchez-Soto, S. & O. Nakano. 2004a. Presença de *Batrachedra nuciferae* Hodges na cultura da coqueira no estado de São Paulo. Revista de Agricultura 79: 155–157.

Sánchez-Soto, S. & O. Nakano. 2004b. Estudo morfológico de *Batrachedra nuciferae* Hodges (Lepidotera: Coleophoridae). Neotropical Entomology 33: 173–178.

Sánchez Soto, S. & O. Nakano. 2008. Biología de *Batrachedra nuciferae* Hodges (Lepidoptera: Coleophoridae), plaga del cocotero en América del Sur. Boletín del Museo de Entomología de la Universidad del Valle 9: 22–26.

Santana, S.W.J. 2008. Criação e bioecologia de *Atheloca subrufella* (Hulst) (Lepidoptera: Phycitidae). Tese de doutorado. Universidade Federal Rural de Pernambuco, Recife, 60 pp.

Santana, S.W.J., R. Barros, J.B. Torres & M.G.C. Gondim Jr. 2010. Exigências Térmicas da Praga do Coqueiro *Atheloca subrufella* (Hulst). (Lepidoptera: Phycitidae). Neotropical Entomology 39: 181–186.

Santana, S.W.J., J.B. Torres, M.G.C. Gondim Jr. & R. Barros. 2009. Infestation of coconut fruits by *Aceria guerreronis* enhances the pest status of the coconut moth *Atheloca subrufella*. Annals of Applied Biology 155: 277–284.

Santana, S.W.J.; R. Barros, J.B. Torres & M.G.C. Gondim Jr. 2011. Técnica de criação e aspectos biológicos de *Atheloca subrufella* (Hulst) (Lepidoptera: Phycitidae) em frutos de coqueiro. Neotropical Entomology 40: 14–19.

Shaffer, J.C. 1995. Phycitinae, pp. 93–105. *In*: Heppner, J.B. (ed.), Atlas of Neotropical Lepidoptera. Checklist: Part 2 Hyblaeoidea – Pyralopidea – Tortricoidea. Association for Tropical Lepidoptera and Scientific Publishers, Gainesville, Florida.

Schotman, C.Y.L. 1989. Plant pests of quarantine importance to the Caribbean. RLAC-PROVEG, No. 21, Food and Agriculture Organisation of the United Nations, 80 pp.

Solis, M.A. 1993. A phylogenetic analysis and reclassification of the genera of the *Pococera* complex (Lepidoptera: Pyralidae: Epipaschiinae). Journal of the New York Entomological Society 101: 1–83.

Solis, M.A. 2011. Key to selected Pyraloidea (Lepidoptera) larvae intercepted at U. S. ports of entry: revision of Pyraloidea in "keys to some frequently intercepted lepidopterous larvae" by Weisman 1986. http://www.ars.usda.gov/Services/docs.htm?docid=21551. 58 pp.

Swezey, O.H. 1909. The Hawaiian sugar cane bud moth (*Ereunetis flavistriata*) with an account of some allied species and natural enemies. Hawaiian Sugar Planters' Association Experimental Station, Entomological Bulletin 6: 1–40, plates 1–4.

Swezey, O.H. 1910. The feeding habits of Hawaiian Lepidoptera. Proceedings of the Hawaiian Entomological Society 2: 131–143.

Taylor, T.H.C. 1930. Early nutfall from coconut palms in Fiji with special reference to insects attacking the flowers. Bulletin of the Department of Agriculture, Fiji 17: 1–42.

Trebrown Nurseries. 2011. Classification of Palm Trees [Arecaceae]. http://www.trebrown.com/palms_arecaceae_order.php (Last accessed 19 Dec 2012).

van Nieukerken, E.J., L. Kaila, I.J. Kitching, N.P. Kristensen, D.C. Lees, J. Minet, C. Mitter, M. Mutanen, J.C. Regier, T.J. Simonsen, N. Wahlberg, S.-H. Yen, R. Zahiri, D. Adamski, J. Baixeras, D. Bartsch, B.A. Bengtsson, J.W. Brown, S.R. Bucheli, D.R. Davis, J. De Prins, W. De Prins, M.E. Epstein, P. Gentili-Poole, C. Gielis, P. Hättenschwiler, A. Hausmann, J.D. Holloway, A. Kallies, O. Karsholt, A.Y. Kawahara, S. Koster, M.V. Kozlov, J.D. Lafontaine, G. Lamas, J.-F. Landry, S. Lee, M. Nuss, K.-T. Park, C. Penz, J. Rota, A. Schintlmeister, B.C. Schmidt, J.-C. Sohn, M.A. Solis, G.M. Tarmann, A.D. Warren, S. Weller, R.V. Yakovlev, V.V. Zolotuhin & Zwick, A. 2011. Order Lepidoptera Linnaeus, 1758, pp. 212–221. *In*: Zhang, Z.-Q. (ed.), Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. Zootaxa 3148: 1–237.

Velázquez, J., J.L. García, Y. Romero & M. Medina. 2010. *Phidotricha erigens* Ragonot, 1888 (Lepidoptera: Pyralidae), causando daño en *Agave cocui* Trelease, en el estado Falcón, Venezuela. Algunos aspectos de su biología y su control natural. Entomotropica 25: 117–124.

Vesey-Fitzgerald, D. 1941. Some insects of economic importance in Seychelles. Bulletin of Entomological Research 32: 153–160.

Walsingham, Lord. 1882. Notes on Tineidae of North America. Transactions of the American Entomological Society 10: 165–204.

Walsingham, Lord. 1897. Revision of the West-Indian Micro-Lepidoptera with descriptions of new species. Proceedings of the Zoological Society of London 1897: 54–183.

Walsingham, Lord. 1891. On the Micro-Lepidoptera of the West Indies. Proceedings of the Zoological Society of London 1891: 491–549, plate XLI.

Waterhouse, D.F. & K.R. Norris. 1987. 26. *Tirathaba rufivena* (Walker), pp. 211–218. *In*: Waterhouse, D.F. and K.R. Norris, Biological Control: Pacific Prospects. Inkata Press, Melbourne, Australia.

Zimmerman, E. C. 1978. Microlepidoptera. Part 2, Gelechioidea. Insects of Hawaii 9(2), pp. 883–1903, figs 608–1355. University of Hawaii Press, Honolulu, Hawaii.